Several archaeological sites have been excavated within the Route 301 study area north of the C&D Canal. These include continued occupation of the Hawthorn site (Coleman et al. 1984), the Williams site (Catts and Custer 1990), and the Dickson site (Catts et al. 1989a). Several sites occupied between 1830 and 1880 were investigated by Lothrop et al. (1987) including the Clarksdale Tenancy No. 1 (7NC-D-111) and the Cazier Tenancy #2 (7NC-F-64). The Clarksdale Tenancy was test excavated revealing a stone foundation disturbed by later construction (Lothrop et al. 1987:178). The Cazier Tenancy was considered eligible for the National Register of Historic Places and underwent full scale excavations (Hoseth et al. In press).

Several other sites near the Route 301 study area were occupied after 1830. The Wilson-Slack site (CRS No. N-6269) was a combination agricultural complex and blacksmith/machine shop and mill (Coleman et al. 1985). The Temple site (7NC-D-68), in Ogletown, was larger than other non-owner occupied houses and was probably used by farm managers employed by the larger land owner (Hoseth et al. 1990). The Allen House site (7NC-E-78), east of Christiana, probably served a variety of purposes, beginning as a tenant house (Basalik et al. 1987). Later, the site was owner occupied and served as a dwelling, workshop, and tavern (Basalik et al. 1987:105-112).

**1880-1940**

The number of historic resources falling into this time period decreases to 213: 51 (23.9%) BAHP Standing Structures, 62 (29.1%) Potential Standing Structures, and 98 (46.0%) Potential Archaeological Sites (Table 6). Unknown functions dominate because functions were difficult to infer from the 1906 Quadrangle map from which the majority of the data for this time period were drawn.

Occupations begun earlier continued at a number of sites in the study area (eg., Hawthorn and Dickson) and sites nearby (eg., Temple and Allen). Most sites that have been excavated have been tenant houses, perhaps because the highway improvements thatnecessitated the archaeological research involved widening of existing roads. As shown in Table 30 (see later discussion), tenant houses tend to be closer to roads than do owner-occupied farm complexes.

**Summary**

The over 1100 historic resources documented in this study include a sample of almost every type of historic activity that has taken place during the last 360 years in northern Delaware. The majority of the activities are related to the agricultural production and the support network of processing and transportation. The majority of the study area was not involved in the manufacturing developments that influenced the Piedmont, with its steeper drainages, and the urban center of Wilmington.

Only 3.1% (34) of the total potential historic resources in the Route 301 study area (1111 localities) have been investigated archaeologically. Large gaps exist in the archaeological knowledge of New Castle County, especially of the earliest occupations of the area. There may also be a bias in the types of sites that have been investigated. The historical significance and archaeological potential of sites are dependent on both particular features and circumstances at individual localities and more general issues and trends in the region.

## PREDICTIVE MODELS

The archaeological sites and standing structures documented in the state records do not comprise all of the cultural resources in the study area and, furthermore, may not be representative of past activities and settlement in the study area. Therefore, it is necessary to estimate the archaeological potential of a large region, such as the Route 301 study area, to allow management and planning decisions. This section describes the development and application of predictive models to the prehistoric and historic archaeology of the study area.

## PREHISTORIC SITES

Predictive models must be applied to the study of prehistoric archaeological resources for a number of reasons. A complete inventory of all prehistoric archaeological sites through field research is not possible due to a variety of constraints (Schiffer and House 1975). Recorded archaeological sites usually reflect modern activity, such as farming, that bring cultural material to light. Previous archaeological research may also be biased due to limitations on survey coverage. Thus, it is necessary to develop predictive models to fill in gaps in our knowledge.

Predictive models for prehistoric sites can be created in many different ways (Kohler 1988). Deductive models, such as that of Jochim (1976), use detailed analyses of modern resources and analogies to living hunter-gatherer populations to derive the likely localities of past hunter-gatherer activities. Because of difficulties in obtaining detailed environmental data and the poor resolution of available paleoenvironmental data, the projections of these models and their predictions into the more distant past are tenuous at best (Binford 1978). Also, empirical data from known archaeological sites on the Middle Atlantic coastal plain (Custer et al. 1986a; McNamara 1982) have contradicted such models applied to the region (eg., Cameron 1976).

An empirical approach to building predictive models compares the location of known sites to environmental data through statistical analyses (Gardner 1978, 1982; Grady 1980; Kellogg 1987; Kenyon and McDowell 1983; Lafferty et al. 1981; Mathes 1970; Zarky 1976). In Delaware, Custer (1980), Wells et al. (1981), Custer and Galasso (1983), and Eveleigh et al. (1983) have derived probability maps for site distributions based on controlled site surveys with recognized success (Ebert 1988:461).

Predictive models result in descriptions of typical site locations. The descriptions may be in the form of listings of significant variables (Gardner 1978; Cunningham 1983), narrative descriptions of typical site locations (Stewart 1981; Wall 1981; Tolley 1983), diagrams of site locations (Hoffman and Foss 1980; Custer and Wallace 1982; Custer 1983, 1984a, 1989a), descriptions of site locations using quantitative data (Hughes and Weissman 1982), or quantitative projections of numbers and types of sites within different environmental zones (Custer 1983; Custer and Galasso 1983). All of these types of predictions can be used for resource management and further research and testing.

Schematic models of prehistoric settlement for cultural time periods have been developed by Custer (1984a). Figure 28 shows a model for Paleo-Indian and Archaic settlement and Table 15 gives a description of typical Paleo-Indian and Archaic period site locations.

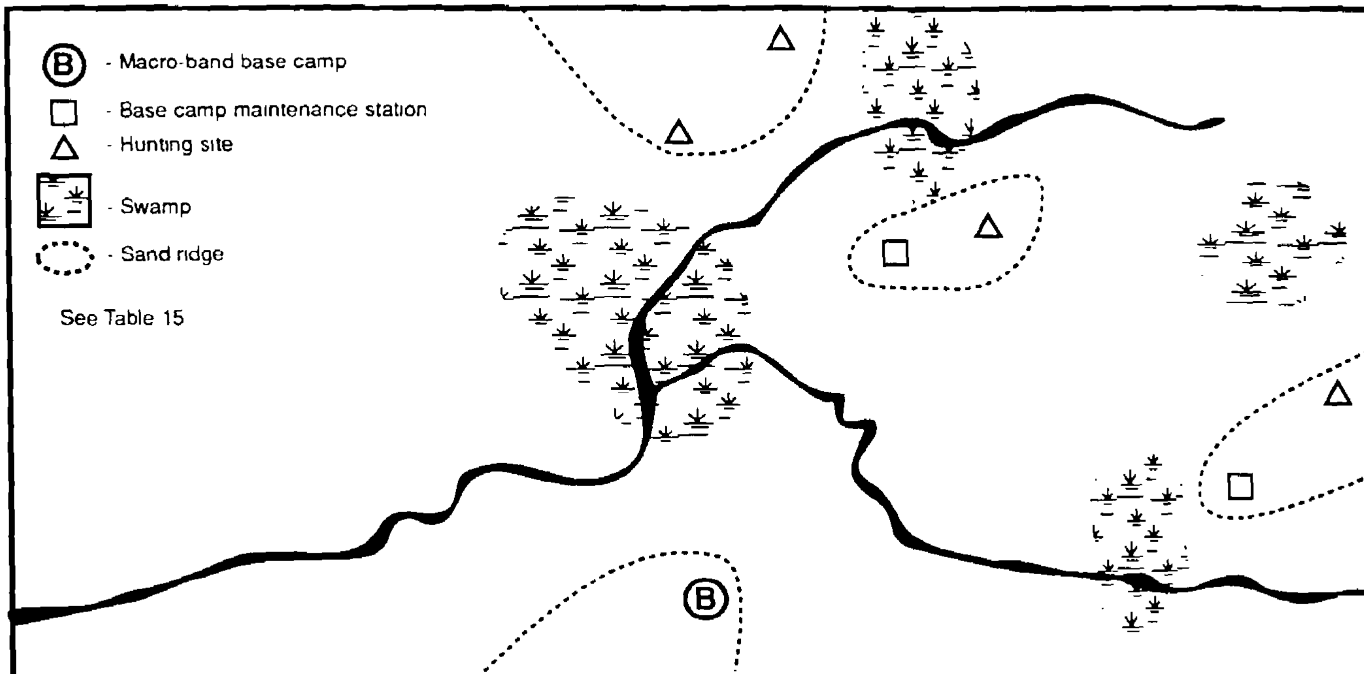
Woodland I sites are the most common sites in the study area. Settlement pattern during the Woodland I is not much different from earlier periods. However, Woodland I settlement is more intensive. Figure 29 shows the general model of Woodland I settlement and site types and the possible groups movements among the site types. Table 16 gives descriptions for typical site settings for both riverine and interior portions of the study area. Woodland II settlement patterns differ little from those of the Woodland I period.

The models discussed above provide a general guide to the types of locations used by prehistoric peoples in Delaware. However, these schematics are not specific to real localities. It is necessary to carry out additional analysis of a region to produce predictions. Previous studies in Delaware, undertaken by the University of Delaware Center for Archaeological Research, have used quantitative analysis and satellite remote sensing to relate known site locations to actual landscapes and to derive predictive models (Custer et al. 1984; Custer et al. 1986a; Eveleigh et al. 1983).

In summary, the technique developed by the University of Delaware uses Landsat satellite data to derive a land classification based on the light reflected from the earth's surface into space. The reflected light data are stored in digital form andcan be manipulated by computers (Klemas 1977). The satellite land classification for known site locations is compared to a sample of non-site locations using logistic regression (Custer et al. 1986a; Eveleigh 1984; Wells 1981). The logistic regression results in a mathematical equation that discriminates between likely site locations and unlikely site locations. Feeding the satellite land classification into the logistic regression equation yields a probability map of site locations for a study area.

## FIGURE 28

# Paleo-Indian / Archaic Settlement Model




A schematic model of Paleo-Indian and Archaic period settlement patterns. A variety of environments could be used from macro-band base camps where family groups camped together. Maintenance stations and hunting camps were occupied by either family units or other subsets of the band. Base camps were changed frequently as the band moved in search of game animals and other food sources.

**TABLE 15**

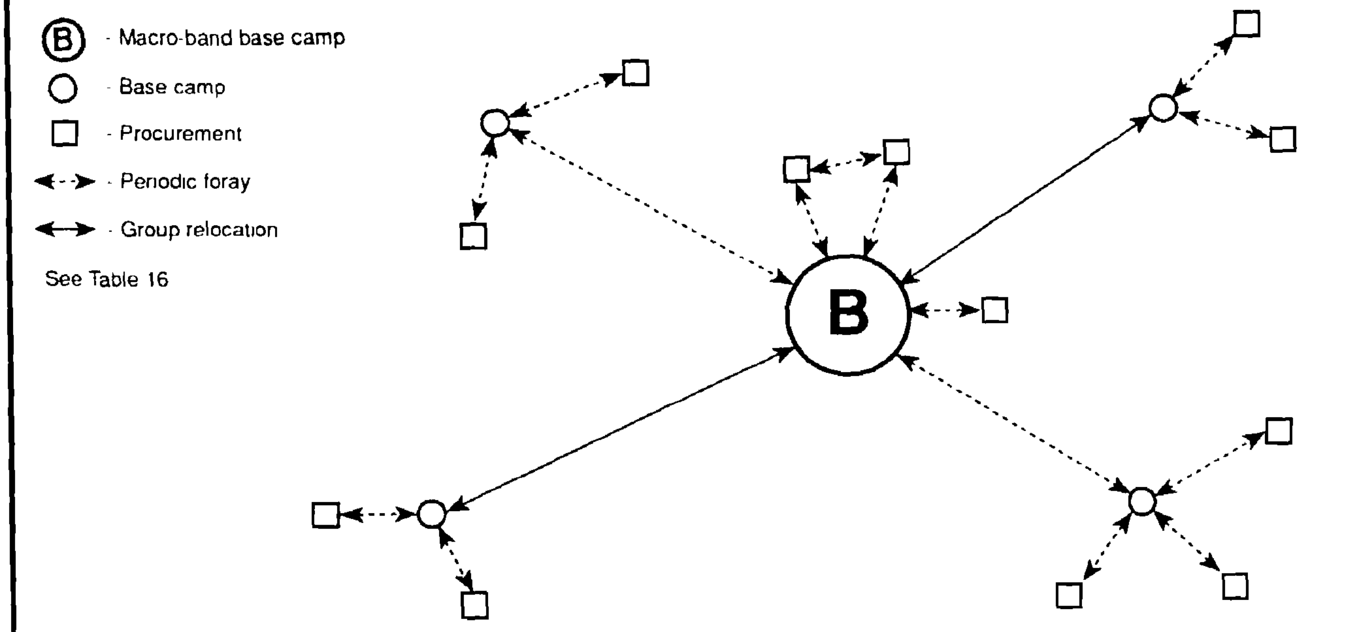
**PALEO-INDIAN SITE LOCATION MODEL**

| Site Types | Locations |
|---|---|
| Base camp | well-drained ridge in areas of maximum habitat overlap |
| Base camp maintenance station | game attractive locale close to base camp (swamps, bay/basin) |
| Hunting site | game attractive locales away from base camp (swamps, bay/basin) |

**Keyed to Figure 28**

FIGURE 29

# Woodland I and II Settlement Model




A schematic model of Woodland period settlement pattern. The macro-band base camp represents villages occupied for longer and longer portions of the year through time. Small groups exploited the landscape around the village on relatively short forays throughout the year. Macro-band base camps may have been changed seasonally.

The predictive model has been subjected to several tests: two planning studies of the Route 13 Corridor (Custer et al. 1986a; Custer and Bachman 1986a), the Phase I survey of the final Route 13 Early Action Segment (Bachman et al. 1988), a survey of the Murderkill drainage specifically focused on testing the LANDSAT predictive model (Gelburd 1988), and the test data generated from the original St. Jones/Murderkill survey (Eveleigh et al. 1983). Table 17 summarizes the test results from these studies. In all cases there are no statistically significant differences between model expectations and the observed results of surveys.

Updates in equipment and software for satellite remote sensing at the University of Delaware have required revisions in the procedure developed by Eveliegh (1984). Customized FORTRAN programs were written to duplicate the logistic regression model on the new facilities (Kellogg 1990). The revised programs reproduced the results of Eveleigh (1984) and Custer et al. (1986a) for the St. Jones/Murderkill region based on the original data.

In attempting to apply the satellite/logistic regression method to the Route 301 study area three problems were encountered:

1) the satellite coverage used in the past does not include the northern third of the area;
2) the model relationships developed in the past apply to the low coastal plain, not the high coastal plain of the northern half of the study area; and
3) development and modern transformation of the landscape has obscured the natural environment of the study area north of the C&D Canal.

For example, 41 known sites in the Route 301 study area fell into the area covered by the Landsat photo. Of these only 41% were at High probability localities. Custer and Bachman (1986a:114-126) compared two applications of

## TABLE 16

### WOODLAND I AND II STUDY UNITS AND SITE LOCATION MODEL

| Study Units | Data Quality | Site Types | Location |
|---|---|---|---|
| Riverine Zone | fair base camp | macro-band | low terraces of major drainages at stream confluences and at saltwater/fresh water interface of the marsh |
| | | micro-band base camp | confluences of low order streams and tidal marshes |
| | | procurement sites | along minor and ephemeral drainages adjacent to poorly drained woodlands and on small sand ridges and knolls |
| Interior Zone | poor | micro-band base camp | well-drained knolls at springs and stream confluences |
| | | procurement sites | well-drained knolls at swamps and springs |

(Table taken from Catts et al. 1990)

**Keyed to Figure 29**

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the Landsat/logistic regression model to areas within the Route 13 study area. In the Appoquinimink study area 61% of sites fell within the High probability zone, but only 12.7% of sites in the Blackbird area fell in the High probability zone. A major difference between the two areas is the presence of bay/basin features that are difficult to detect on the satellite images in the Blackbird area.

We have used the Landsat-based predictive model only for the area south of the Canal, an area immediately west of the Appoquinimink study area of Route 13. Probability values were grouped as follows:

High probability = likelihood value > 0.70;
Medium probability = likelihood values between 0.50 and 0.70;
Low probability = likelihood values less than 0.50.

It should be noted that the Low probability zone is not devoid of sites. Sites may still be present, but they will be present in significantly lower frequencies compared to the Medium and High probability zones. The predictions are contoured from a 100m grid.

## TABLE 17

## LANDSAT PREDICTIVE MODEL TEST RESULTS

**Route 13 Phase I Survey (Bachman, Custer, and Grettler 1988)**

| Probability Zone | Total # of Quadrats | Expected # With Sites | Observed # With Sites |
|---|---|---|---|
| H | 8 | 7 | 1 |
| M | 25 | 15 | 4 |
| L | 223 | 22 | 19 |

Chi-square = 2.88, $.25 < p < .50$

**Murderkill Drainage Survey (Gelburd 1988)**

| Probability Zone | Total # of Quadrats | Expected # With Sites | Observed # With Sites |
|---|---|---|---|
| H | 4 | 4 | 4 |
| M | 17 | 11 | 15 |
| L | 56 | 14 | 10 |

Chi-square = 1.53, $0.1 < p < 0.25$

**Route 13 Planning Study, Kent County (Custer, Bachman, and Grettler (1986)**

| Probability Zone | Total # of Quadrats | Expected # With Sites | Observed # With Sites |
|---|---|---|---|
| H | 36 | 32 | 28 |
| M | 110 | 69 | 74 |
| L | 96 | 24 | 23 |

Chi-square = .9, $0.25 < p < 0.50$

**Route 13 Planning Study, New Castle County (Custer and Bachman 1986)**

| Probability Zone | Total # of Quadrats | Expected # With Sites | Observed # With Sites |
|---|---|---|---|
| H | 19 | 17 | 17 |
| M | 37 | 23 | 27 |
| L | 19 | 5 | 7 |

Chi-square = 1.16, $0.25 < p < 0.50$

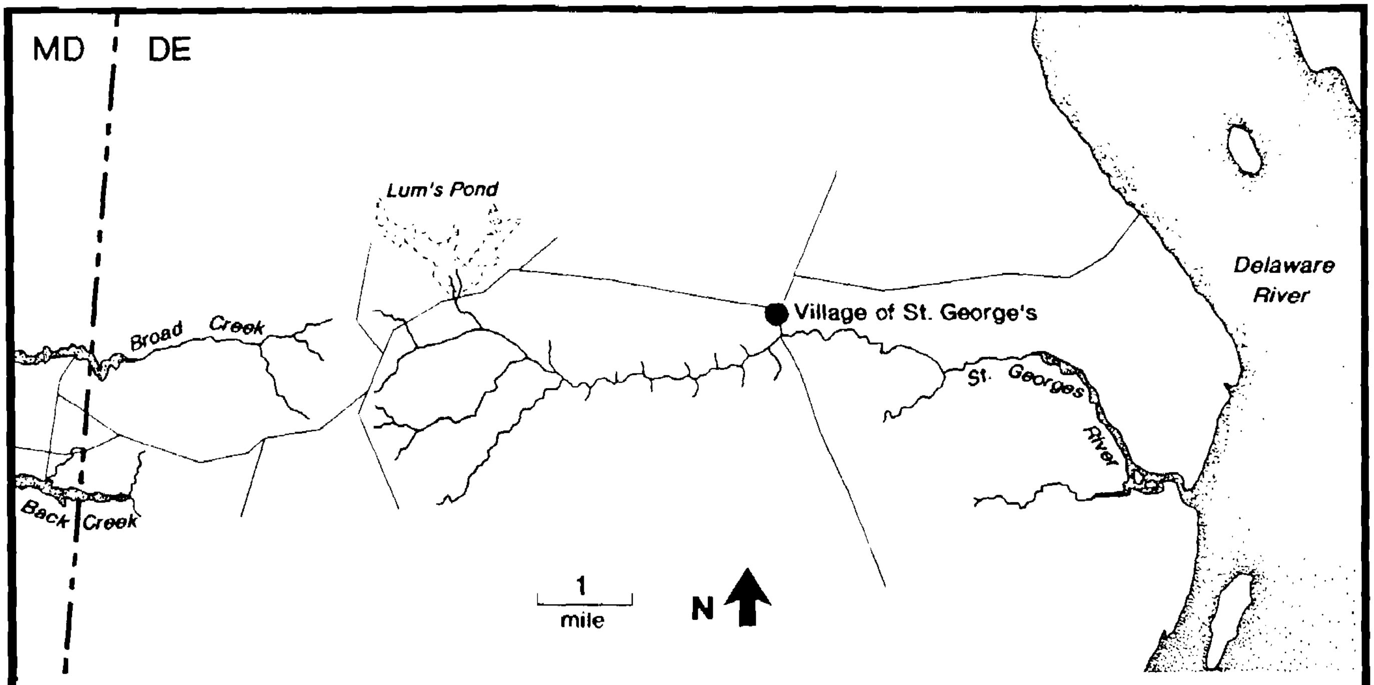
**St. Jones/Murderkill Test Data (Eveleigh, Custer, Klemas 1983)**

| Probability Zone | Total # of Quadrats | Expected # With Sites | Observed # With Sites |
|---|---|---|---|
| H | 47 | 41 | 45 |
| M | 34 | 21 | 29 |

Chi-square = 3.44, $0.10 < p < 0.25$

## FIGURE 30

# Pre-C&D Canal Drainages




A reconstruction of the St. George river drainage before the construction of the C&D Canal. Lums Pond was established by damming the northernmost branches of the St. Georges River and was originally a mill pond. Based on Snyder and Guss (1974) and Latrobe's 1804 map.

For the area north of the canal a new predictive model was developed. Wells (1981) used an environmental data base developed by New Castle County - the Automated Environmental Resources Information System (AERIS) - as input to his logistic regression model. The same data base was used in this study to develop both prehistoric and historic predictive models.

The AERIS data are coded for 500 foot grid cells oriented to the Delaware State Plane grid. Over thirty environmental and other variables are recorded for each grid cell. For the purposes of this study, soil and surface water variables were obtained from the New Castle County Department of Water Resources. These data were converted to a form that could be manipulated by the ERDAS software for satellite remote sensing, using a custom FORTRAN program, and provide a Geographic Information System (GIS) for the study area.

Although Wells (1981) study included six variables, analysis of prehistoric site locations in Delaware, including the Landsat-based models, have shown that surface water and soil moisture conditions are the most important correlates to prehistoric sites outside of the coastal zone (Custer and Bachman 1986a:126-131; Custer et al. 1986a:172-177). Custer and Bachman (1986a:127-128), for example, note that locations adjacent to streams characterize 71% of all sites in all time periods, and Lothrop et al. (1987:28-31) found that 31 of 34 sites were within 200m of water and 18 of the 31 sites were within 100m of water.

Another important correlate to prehistoric settlement in the region is soil moisture, especially the presence of "bay/basin" features where poorly-drained soils occur and standing water may be found seasonally (Custer and Bachman 1986a:129, 145-149; Lothrop et al. 1987:33). Weslager (1972:32) also notes that nearness to water and soil variables were important locational criteria to the "Delaware Indians".

The AERIS data for drainages was edited to remove man-made lakes and to restore the pre-C&D Canal drainage network as determined by the study of maps, documents, and published references (eg., Snyder and Guss 1974:15-26; Figure 30). Edge effects in the analysis were eliminated by including drainages in Maryland and a buffer zone around the study area. Soils information in the AERIS data base were derived directly from the U.S. Soil Conservation Service mapping for New Castle County (Matthews and Lavoie 1970). The soil data was recoded to indicate whether or not a grid cell is dominated by poorly-drained soils and to indicate if both wet and dry soils occurred in a grid cell (presence of a soil ecotone). A buffer zone of at least 12,500ft (25 grid cells) was included on three sides of the study area. Along the Maryland border data for soil drainage was gridded by hand from Andersen and Matthews (1973) Soil Survey of Cecil County to provide a buffer of at least 5 grid cells (2500 feet) because preliminary analysis showed that additional buffering was unnecessary.

The data for five variables were compared to the distribution, by AERIS grid square, of 111 grid cells with known prehistoric archaeological sites within the Route 301 study area:

1) drainage presence/absence;
2) distance to drainage (Table 18);
3) poorly-drained soil presence/absence;
4) wet/dry soil ecotone presence/absence, and;
5) distance to wet/dry soil ecotone (Table 19).

Only the distance variables were found to be significant. The predictive model for prehistoric sites included here was generated by taking the minimum distance (in 500 foot grid squares) to a drainage of any type or the to wet/dry soil ecotone up to a value of 26 (> 25 grid squares). Based on the statistical analysis of known site locations and previous study results, three probability zones were defined (Figure 31):

1) High - grid squares with drainage or with a wet/dry soil ecotone present;
2) Medium - distance of one grid square for either variable; and;
3) Low - greater than one grid square away from a drainage or wet/dry soil ecotone.

Of the 111 grid squares known to contain sites 62.2% fall in to the High probability zone, 30.6% fall into the Medium zone, and only 7.2% fall into the Low probability zone (Table 20). However, 49.1% of the study area falls into the High probability zone. The model is accurate, but not precise. The Landsat based predictive model is useful south of the C&D Canal. This model was resampled and rectified from the UTM grid to the Delaware State Plane grid to compare it to the model developed using the AERIS data. Table 21 is a cross-tabulation of the two models. The AERIS-based model places 20% more grid squares into the High probability zone than Landsat-based model. The Landsat-based model, on the other hand has a much larger Medium probability zone than does the AERIS-based model. The two models exactly concur in 28.7% of the 3352 grid squares south of the C&D Canal. The differences between the two models are largely due to the ways they classify wetlands. The Landsat-based model is most strongly influenced by <u>existing</u> wetlands as represented by brackish and salt water marshes and unfarmed, tree covered areas. The AERIS model is based on the Wetland suitability rating of soilsin the study area (Matthews and Lavoie 1970:54-57), thus it is influenced by <u>potential</u> wetlands.

The Route 301 study area is crossed by many drainages leading from the Piedmont zone to the north. The western portion of the study area, north of the C&D Canal, contains large areas of poorly-drained soils. An assumption in this analysis is that the known archaeological sites are representative of all the sites in the region. Because no comprehensive large scale surveys have been undertaken in the study area there is no alternative to accepting this assumption at this time. The predictive model presented above is based on the best information available and concurs with the results of many other studies in Delaware.

## TABLE 18

## RELATIONSHIP BETWEEN PREHISTORIC SITES AND DRAINAGES

| Distance Class* | Background: Grid Squares** | Background: % | Sites: Grid Squares** | Sites: % |
|---|---|---|---|---|
| 0 | 1694. | 15.12 % | 24. | 21.62 % |
| 1 | 3445. | 30.74 % | 45. | 40.54 % |
| 2 | 1948. | 17.38 % | 21. | 18.92 % |
| 3 | 1398. | 12.48 % | 8. | 7.21 % |
| 4 | 1241. | 11.07 % | 7. | 6.31 % |
| 5 | 536. | 4.78 % | 1. | 0.90 % |
| 6 | 465. | 4.15 % | 4. | 3.60 % |
| 7 | 240. | 2.14 % | 1. | 0.90 % |
| 8 | 146. | 1.30 % | 0. | 0.00 % |
| 9 | 74. | 0.66 % | 0. | 0.00 % |
| 10 | 18. | 0.16 % | 0. | 0.00 % |
| 11 | 1. | 0.01 % | 0. | 0.00 % |
| 12 | 0. | 0.00 % | 0. | 0.00 % |
| TOTALS | 11206. | 100.00 % | 111. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Sites are uniformly distributed with respect to distance to drainages.

Ha: Sites are closer to Drainages than grid squares in general (one-sided test).

Smirnov Test Statistic = 0.1784 > 0.155; 0.995 < p.

Reject Ho. Sites are closer to drainages.

## TABLE 19

## RELATIONSHIP BETWEEN PREHISTORIC SITES AND SOIL ECOTONES

| | Background | | Sites | |
|---|---|---|---|---|
| Distance Class* | Grid Squares** | % | Grid Squares** | % |
| 0 | 4938. | 44.07 % | 61. | 54.95 % |
| 1 | 4040. | 36.05 % | 40. | 36.04 % |
| 2 | 1209. | 10.79 % | 4. | 3.60 % |
| 3 | 581. | 5.18 % | 3. | 2.70 % |
| 4 | 332. | 2.96 % | 3. | 2.70 % |
| 5 | 82. | 0.73 % | 0. | 0.00 % |
| 6 | 22. | 0.20 % | 0. | 0.00 % |
| 7 | 2. | 0.02 % | 0. | 0.00 % |
| 8 | 0. | 0.00 % | 0. | 0.00 % |
| 9 | 0. | 0.00 % | 0. | 0.00 % |
| 10 | 0. | 0.00 % | 0. | 0.00 % |
| TOTALS | 11206. | 100.00 % | 111. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Sites are uniformly distributed with respect to distance to Wet/Dry soil ecotone.

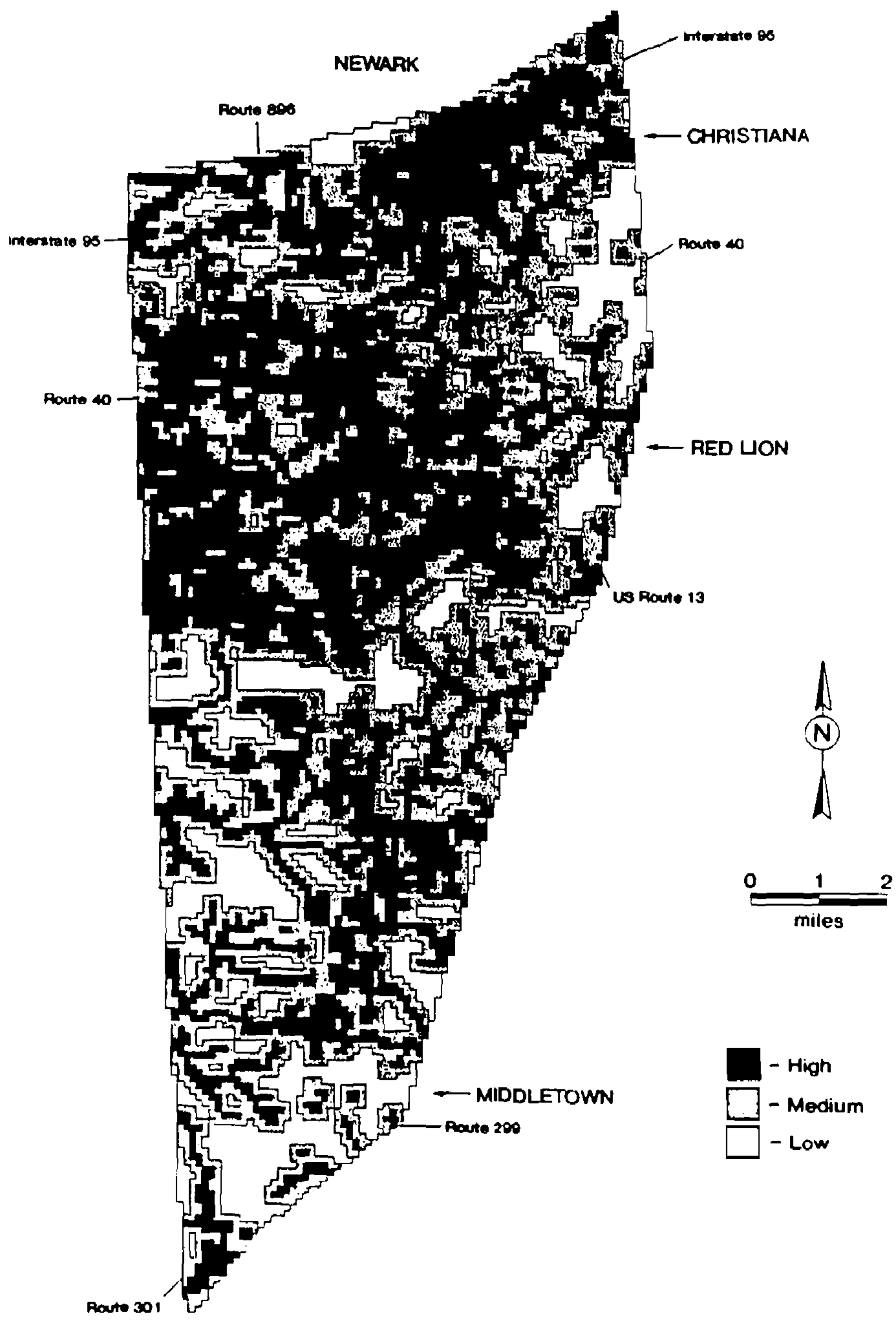
Ha: Sites are closer to Wet/Dry soil ecotones than grid squares in general (one-sided test).

Smirnov Test Statistic = 0.1088 > 0.1021; 0.90 < p.

Reject Ho. Sites are close to Wet/Dry soil ecotones (at Alpha = 0.10).

# FIGURE 31

# Prehistoric Predictive Zones for the Study Area




Predictive model for prehistoric archaeological sites in the Route 301 study area. Based on distance to drainages and distance to wet/dry soil ecotone coded for a five hundred foot grid established by the New Castle County Department of Water Resources. Large areas in the northern half of the study area map as High Probability because of the patches of poorly drained soils in the area.

## TABLE 20

### RELATIONSHIP BETWEEN PREHISTORIC SITES AND DRAINAGES OR SOIL ECOTONES

| Distance Class* | Background: Grid Squares* | Background: % | Sites: Grid Squares** | Sites: % | Predictive Zones |
|---|---|---|---|---|---|
| 0 | 5502. | 49.10 % | 69. | 62.16 % | High |
| 1 | 3933. | 35.10 % | 34. | 30.63 % | Medium |
| 2 | 1066. | 9.13 % | 5. | 4.50 % | Low |
| 3 | 468. | 4.18 % | 1. | 0.90 % | \| |
| 4 | 195. | 1.74 % | 2. | 1.80 % | V |
| 5 | 35. | 0.31 % | 0. | 0.00 % | |
| 6 | 7. | 0.31 % | 0. | 0.00 % | |
| 7 | 2. | 0.06 % | 0. | 0.00 % | |
| 8 | 0. | 0.00 % | 0. | 0.00 % | |
| 9 | 0. | 0.00 % | 0. | 0.00 % | |
| 10 | 0. | 0.00 % | 0. | 0.00 % | |
| TOTALS | 11206. | 100.00 % | 111 | 100.00 % | |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Sites are uniformly distributed with respect to the minimum distance to drainages or wet/dry soil ecotone.

Ha: Sites are closer to drainages or wet/dry soil ecotones than locations in general (one-sided test).

Smirnov Test Statistic = 0.13 > 0.1297; 0.975 < p.

Reject Ho. Sites are close to drainages or wet/dry soil ecotones.

## TABLE 21

## COMPARISON OF AERIS-DATA AND LANDSAT-DATA BASED PREDICTIVE MODELS

**AERIS-Data Based Model**

| Landsat Data Model | High | Medium | Low | Totals (%) |
|---|---|---|---|---|
| **High** | 198 (5.9%) | 221 | 105 | 524 (15.6) |
| **Medium** | 451 | 670 (19.1%) | 640 | 1761 (52.6) |
| **Low** | 551 | 422 | 94 (2.8%) | 1067 (31.8) |
| **Totals** (%) | 1200 (35.8) | 1313 (39.2) | 839 (25.0) | 3352 |

Notes: Percentages along the diagonal of the table show the exact coincidence of the probability classes between the two models. Totals for the rows and columns pertain to the individual predictive models.

## HISTORIC SITES

Predictive models are presented for the earliest periods of Historic occupation in the study area - 1630-1730, and 1730-1770. Later occupation of New Castle County is well documented by maps, surveys, and legal documents. Detailed maps covering northern Delaware show roads, drainages, public buildings, individual farms, businesses, churches, and also individual dwellings with increasing accuracy through time starting in about 1820. Plots of potential sites, documented standing structures (those with CRS numbers), and potential standing structures clearly show the patterns of settlement after the beginning of nineteenth century (See Attachments). Detailed information is lacking for the earliest historic occupation of the study area, therefore, predictive models were produced.

### 1630-1730

Early settlement in the region was tied to the available transportation network. At the start of European colonization the major means of egress into the land was by navigable waterways. Later, roads were cleared between points of navigation and settlement expanded inland. Walzer (1972:163) estimated that greater than half of all farmsteads established prior to about 1770 were within eight miles of a mill or shipping wharf. All of the Route 301 study area, and almost all of New Castle County for that matter, meets that criteria, but navigable drainages do not extend far into western New Castle County. Wise (1980:4) found that historic sites prior to 1730 were all located within 300 feet of a drainage. Navigable drainages identified on historical maps (eg., Munroe and Dann 1985) were digitized and then converted to the AERIS grid for use in predictive models. Distance to navigable drainage was computed in grid squares (Table 22) using the ERDAS package for satellite photo analysis at the University of Delaware Center for Remote Sensing, Department of Marine Studies. Roads were first established in New Castle County to connect settlements along different navigable drainages, and to connect the Delaware settlements with those on the eastern shore of Maryland and north and south along the Delaware River and Bay. A road ran from Augustus Herman's plantation to New Castle by 1671 and from New Castle to present Odessa by 1678 (Scharf 1888:413). Another road ran from Odessa to Casperus Herman's "Bohemia Manor" by 1679. Court records and early maps show the development of the inland transportation network. Dwellings were seldom at any great distance from a road. Distance to the road network prior to 1730 was determined by digitizing, as nearly as could be established, the route of early roads from quadrangle maps. The road network was then gridded to match the AERIS grid. Distance was calculated using the ERDAS package (Table 23).

## TABLE 22

### PRE-1730 HISTORIC SITES
### vs.
### DISTANCE TO NAVIGABLE DRAINAGES

| | Background | | Sites | |
|---|---|---|---|---|
| Distance Class* | Grid Squares** | % | Grid Squares** | % |
| 0 | 34. | 0.30 % | 2. | 9.52 % |
| 1 | 87. | 0.77 % | 4. | 19.05 % |
| 2 | 72. | 0.64 % | 4. | 19.05 % |
| 3 | 75. | 0.66 % | 5. | 23.81 % |
| 4 | 120. | 1.06 % | 1. | 4.76 % |
| 5 | 104. | 0.92 % | 0. | 0.00 % |
| 6 | 131. | 1.16 % | 0. | 0.00 % |
| 7 | 130. | 1.15 % | 0. | 0.00 % |
| 8 | 154. | 1.36 % | 0. | 0.00 % |
| 9 | 206. | 1.82 % | 0. | 0.00 % |
| 10 | 172. | 1.52 % | 0. | 0.00 % |
| 11 | 215. | 1.90 % | 0. | 0.00 % |
| 12 | 201. | 1.78 % | 0. | 0.00 % |
| 13 | 259. | 2.29 % | 1. | 4.76 % |
| 14 | 250. | 2.21 % | 0. | 0.00 % |
| 15 | 330. | 2.92 % | 0. | 0.00 % |
| 16 | 251. | 2.22 % | 0. | 0.00 % |
| 17 | 257. | 2.27 % | 0. | 0.00 % |
| 18 | 366. | 3.24 % | 0. | 0.00 % |
| 19 | 261. | 2.31 % | 0. | 0.00 % |
| 20 | 314. | 2.78 % | 0. | 0.00 % |
| 21 | 255. | 2.26 % | 0. | 0.00 % |
| 22 | 286. | 2.53 % | 0. | 0.00 % |
| 23 | 328. | 2.90 % | 0. | 0.00 % |
| 24 | 264. | 2.34 % | 0. | 0.00 % |
| 25 | 322. | 2.85 % | 0. | 0.00 % |
| 26 | 5852. | 51.80 % | 5. | 23.81 % |
| TOTALS | 11296. | 100.00 % | 21. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Grid squares with sites are uniformly distributed with respect to Grid Squares with Navigable Drainages.

Ha: Grid squares with sites tend to be closer to Grid Squares with Navigable Drainages (one-sided test).

Smirnov Test Statistic = 0.7276 > 0.356; 0.995 < p.

Reject Ho. Sites are close to Navigable Drainages.

## TABLE 23

### PRE-1730 HISTORIC SITES
### vs.
### DISTANCE TO ROADS

| Distance Class* | Background: Grid Squares** | Background: % | Sites: Grid Squares** | Sites: % |
|---|---|---|---|---|
| 0 | 352. | 3.12 % | 4. | 19.05 % |
| 1 | 939. | 8.31 % | 10. | 47.62 % |
| 2 | 652. | 5.77 % | 3. | 14.29 % |
| 3 | 630. | 5.58 % | 0. | 0.00 % |
| 4 | 820. | 7.26 % | 1. | 4.76 % |
| 5 | 538. | 4.76 % | 0. | 0.00 % |
| 6 | 596. | 5.28 % | 0. | 0.00 % |
| 7 | 470. | 4.16 % | 0. | 0.00 % |
| 8 | 474. | 4.20 % | 0. | 0.00 % |
| 9 | 491. | 4.35 % | 1. | 4.76 % |
| 10 | 358. | 3.17 % | 0. | 0.00 % |
| 11 | 395. | 3.50 % | 0. | 0.00 % |
| 12 | 319. | 2.82 % | 0. | 0.00 % |
| 13 | 369. | 3.27 % | 0. | 0.00 % |
| 14 | 305. | 2.70 % | 1. | 4.76 % |
| 15 | 375. | 3.32 % | 1. | 4.76 % |
| 16 | 246. | 2.18 % | 0. | 0.00 % |
| 17 | 230. | 2.04 % | 0. | 0.00 % |
| 18 | 313. | 2.77 % | 0. | 0.00 % |
| 19 | 209. | 1.85 % | 0. | 0.00 % |
| 20 | 230. | 2.04 % | 0. | 0.00 % |
| 21 | 183. | 1.62 % | 0. | 0.00 % |
| 22 | 205. | 1.81 % | 0. | 0.00 % |
| 23 | 204. | 1.81 % | 0. | 0.00 % |
| 24 | 150. | 1.33 % | 0. | 0.00 % |
| 25 | 153. | 1.35 % | 0. | 0.00 % |
| 26 | 1090. | 9.65 % | 0. | 0.00 % |
| TOTALS | 11296. | 100.00 % | 21. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Grid squares with sites are distributed uniformly with respect to Distance to roads.

Ha: Grid squares with sites tend to be closer to roads than grid squares in general (one-sided test).

Smirnov Test Statistic = 0.6376 > 0.3560; 0.995 < p.

Reject Ho. Sites are close to roads.

## TABLE 24

### PRE-1730 HISTORIC SITES
### vs.
### WET vs. DRY SOIL

| Soil Class | Background: Grid Squares | Background: % | Sites: Grid Squares | Sites: % |
|---|---|---|---|---|
| No data | 117. | 0.00 % | 0. | 0.00 % |
| Dry | 8845. | 79.12 % | 19. | 90.48 % |
| Wet | 2334. | 20.88 % | 2. | 9.52 % |
| TOTALS | 11296. | 100.00 % | 21 | 100.00 % |

Hypothesis Testing

Ho: Sites are distributed uniformly with respect to soils.
Ha: Sites are not uniformly distributed with respect to soils.

Test Statistic: Chi-square = 1.637, D.F. = 1; $0.7 < p < 0.8$.

Cannot reject Ho at Alpha = 0.05.

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### PRE-1770 HISTORIC SITES
### vs.
### WET vs. DRY SOIL

| Soil Class | Background: Grid Squares | Background: % | Sites: Grid Squares | Sites: % |
|---|---|---|---|---|
| No data | 117. | 0.00 % | 0. | 0.00 % |
| Dry | 8820. | 79.09 % | 44. | 91.67 % |
| Wet | 2332. | 20.91 % | 4. | 8.33 % |
| TOTALS | 11269. | 100.00 % | 48 | 100.00 % |

Hypothesis Testing

Ho: Sites are distributed uniformly with respect to soils.
Ha: Sites are not uniformly distributed with respect to soils.

Test Statistic: Chi-square = 4.58, D.F. = 1; $0.95 < p < 0.975$

Reject Ho at Alpha = 0.05, but not at 0.025.

Comments: Grid squares dominated by wet soils are just as likely to have sites as grid squares dominated by wet soils prior to 1730. By 1770 sites are disproportionately distributed into grid squares according to soil moisture.

An analysis of historic site locations in Delaware by Custer and Grettler (1991) found that soil drainage contrast was an important determinant of settlement location. A soil factor emphasized the contrast between poorly-drained soils and better drained soils. The AERIS soils data were recoded to show which grid squares are dominated by wet vs. dry soils. Comparison of site locations with the gridded soils data for the Route 301 study area showed no significant site preferences for grid squares dominated by dry soils over those dominated by wet soils (Table 24).

A predictive model was constructed by overlaying the distance to navigable drainage data onto the distance to road data and recoding in the ERDAS Geographic Information Modeling module (Table 25). Five classes of settlement likelihood were established. The model was tested by comparing the data on which it was based and its predictions to known locations of sites pre-dating 1730 (Table 26). Twenty-one grid square contained sites of this age based on all of the available information (CRS standing structures, known archaeological sites, potential standing structures, and potential archaeological sites as listed in the Appendices to this report). Of these 76.2% (16) fell within 2000 feet of navigable drainage and 85.7% (18) fell within 2000 feet of a road. Nineteen (90.5%) of the grid squares with known pre-1730 occupations were dominated by dry soil types. Based on this limited test of the predictive model, High probability can be assigned to Zones 1 and 2; the other three zones have approximately equal probabilities for pre-1730 habitations; however, Zone 3 is most likely to contain sites of this age. Zones 4 and 5 are considered Low probability zones (Figure 32).

**1730-1770**

Settlement pattern during the second quarter of the eighteenth century shifted from water-oriented to a more inland focus (Wise 1980). Navigable drainages still linked the sites of the area with the economy of the larger region (Table 27). The only difference between the predictive models produced for the two time periods was the inclusion of additional roads to the GIS (Table 28). The predictive model was produced in the same way as the model for pre-1730 sites (Figure 33).

Forty-eight grid cells contained sites predating 1770, including those occupied prior to 1730 (Table 29). In contrast to the model for pre-1730 sites, only 37.5% (18) of pre-1770 sites fell within 2000 feet of navigable drainages. However, 89.5% (43) fell within 2000 feet of roads.

The change in settlement pattern orientation was reflected in changes in plantation layout and architecture. Starting in the 1740s, Georgian architectural house forms began to appear, and more permanent methods of construction and material types were used (Carson et al. 1981; Herman 1987:26,109-110). Livestock raising continued to be an important occupation of the area's inhabitants, and home manufactures were added to the subsistence economy by the middle of the eighteenth century (Main 1973; Jordan 1914).

**Later Settlement**

Later historic settlement patterns continued to be influenced by the developing transportation network, including the development of railroads and canal building. Predictive models are not necessary because detailed maps of the region began to be published in the nineteenth century. Roads are shown in detail along with public buildings and some farms on Heald's Map of 1820, and structures are shown on Rea and Price's maps of 1849 and 1850. Increasing detail is shown on Beers' 1868 atlas, Hopkin's 1881maps, and Baist's 1893 atlas. Finally, USGS quadrangle maps attempt to show all structures. These maps are the major sources of data for the Potential Standing Structure and Potential Archaeological Site appendices to this report.

In general, historic sites in all periods are located relatively close to roads. Agricultural sites tend to be located at some distance from the road, with other types of sites closer to the road. For example, an analysis of structures shown on Beer's atlas of 1868 shows the tendency for owner occupied farms to be back away from the road, while tenant houses are adjacent to theroad (Table 30). No difference was found between dwellings north and south of the C&D Canal. For both owner occupied and tenant houses the distribution is skewed towards roads; thus, distance to road can be considered as a measure of historic site potential. For example, from Table 30, 87.8% of all dwellings were within approximately 1000 feet of a road in 1868.

## TABLE 25

## CODING MATRIX FOR HISTORIC PREDICTIVE MODELS

**Distance to Roads (in feet)**

| | | ≤1000 | 1000-5000 | >5000 |
|---|---|---|---|---|
| | ≤1000 | 1 | 2 | 3 |
| **Distance to Navigable Drainage (in feet)** | 1000-5000 | 2 | 3 | 4 |
| | >5000 | 3 | 4 | 5 |

## TABLE 26

## PRE-1730 HISTORIC SITES
## vs.
## PRE-1730 HISTORIC SITE MODEL

| | Background | | Sites | | |
|---|---|---|---|---|---|
| Prob. Class | Grid Squares | % | Grid Squares | % | Class Name |
| 1 | 67. | 0.59 % | 9. | 42.86 % | Highest |
| 2 | 404. | 3.58 % | 7. | 33.33 % | High |
| 3 | 2046. | 18.11 % | 2. | 9.52 % | Medium |
| 4 | 3997. | 35.38 % | 1. | 4.76 % | Lower |
| 5 | 4782. | 42.33 % | 2. | 9.52 % | Lowest |
| TOTALS | 11296. | 100.00 | 21 | 100.00 % | |

Hypothesis Testing

Ho: Sites are uniformly distributed in Probability Classes.

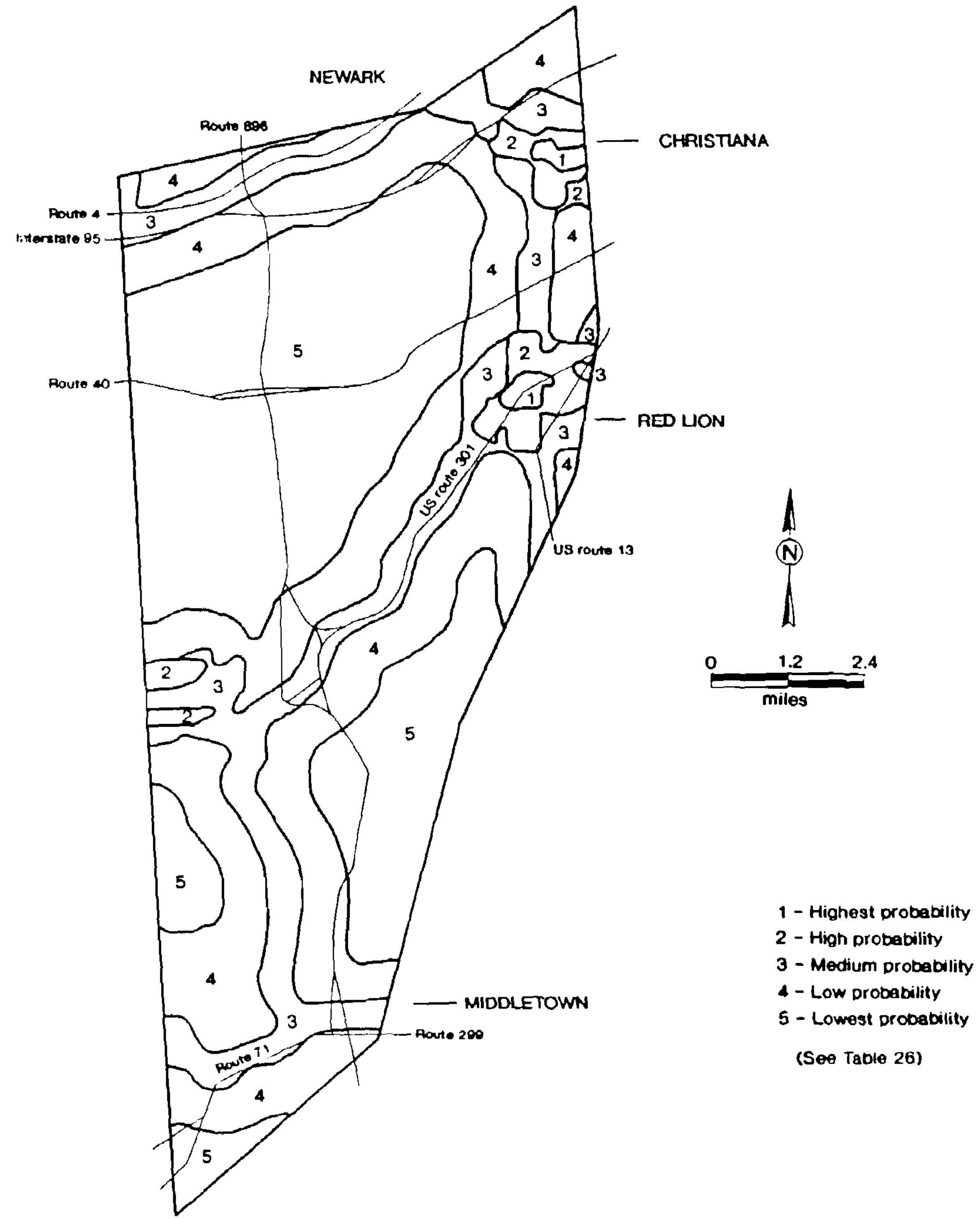
Ha: Sites are not uniformly distributed in Probability Classes (two-sided test).

Smirnov Test Statistic = 0.7202 > 0.356; 0.99 < p.

Reject Ho. Sites are differentially distributed into the probability Classes.

## FIGURE 32

# Pre-1730 Historic Predictive Zones




Predictive model for Pre-1730 historic sites in the Route 301 study area. Based on the distance to navigable drainages and distance to the contemporaneous road network. Some modern roads are shown to orient the reader. The report text gives a full description of how the map was generated.

## TABLE 27

## PRE-1770 HSITORIC SITES
vs.
## DISTANCE TO NAVIGABLE DRAINAGE

| Distance Class* | Background Grid Squares** | % | Sites Grid Squares** | % |
|---|---|---|---|---|
| 0 | 34. | 0.30 % | 2. | 4.17 % |
| 1 | 87. | 0.77 % | 4. | 8.33 % |
| 2 | 71. | 0.63 % | 5. | 10.42 % |
| 3 | 75. | 0.67 % | 5. | 10.42 % |
| 4 | 119. | 1.06 % | 2. | 4.17 % |
| 5 | 104. | 0.92 % | 0. | 0.00 % |
| 6 | 131. | 1.16 % | 0. | 0.00 % |
| 7 | 130. | 1.15 % | 0. | 0.00 % |
| 8 | 153. | 1.36 % | 1. | 2.08 % |
| 9 | 206. | 1.83 % | 0. | 0.00 % |
| 10 | 172. | 1.53 % | 0. | 0.00 % |
| 11 | 214. | 1.90 % | 1. | 2.08 % |
| 12 | 200. | 1.77 % | 1. | 2.08 % |
| 13 | 258. | 2.29 % | 2. | 4.17 % |
| 14 | 250. | 2.22 % | 0. | 0.00 % |
| 15 | 330. | 2.93 % | 0. | 0.00 % |
| 16 | 251. | 2.23 % | 0. | 0.00 % |
| 17 | 257. | 2.28 % | 0. | 0.00 % |
| 18 | 366. | 3.25 % | 0. | 0.00 % |
| 19 | 261. | 2.32 % | 0. | 0.00 % |
| 20 | 314. | 2.79 % | 0. | 0.00 % |
| 21 | 255. | 2.26 % | 0. | 0.00 % |
| 22 | 285. | 2.53 % | 1. | 2.08 % |
| 23 | 328. | 2.91 % | 0. | 0.00 % |
| 24 | 264. | 2.34 % | 0. | 0.00 % |
| 25 | 321. | 2.85 % | 1. | 2.08 % |
| 26 | 5833. | 51.76 % | 24. | 50.00 % |
| TOTALS | 11269. | 100.00 % | 48. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Grid squares with sites are no closer to Navigable Drainages than grid squares in general.

Ha: Grid squares with sites tend to be closer to Navigable Drainages than grid squares in general.

Smirnov Test Statistic = 0.2366 > 0.2357; 0.995 < p.

Reject Ho. Sites tend to be closer to Navigable Drainages.

## TABLE 28

## PRE-1770 HISTORIC SITES
## vs.
## DISTANCE TO ROADS

| | Background | | Sites | |
|---|---|---|---|---|
| Distance Class* | Grid Squares** | % | Grid Squares** | % |
| 0 | 589. | 5.23 % | 17. | 35.42 % |
| 1 | 1549. | 13.75 % | 12. | 25.00 % |
| 2 | 1083. | 9.61 % | 9. | 18.75 % |
| 3 | 1020. | 9.05 % | 3. | 6.25 % |
| 4 | 1288. | 11.42 % | 2. | 4.17 % |
| 5 | 829. | 7.36 % | 2. | 4.17 % |
| 6 | 820. | 7.28 % | 1. | 2.08 % |
| 7 | 629. | 5.58 % | 0. | 0.00 % |
| 8 | 562. | 4.99 % | 0. | 0.00 % |
| 9 | 554. | 4.92 % | 1. | 2.08 % |
| 10 | 364. | 3.23 % | 0. | 0.00 % |
| 11 | 352. | 3.12 % | 0. | 0.00 % |
| 12 | 265. | 2.35 % | 0. | 0.00 % |
| 13 | 245. | 2.17 % | 0. | 0.00 % |
| 14 | 195. | 1.73 % | 0. | 0.00 % |
| 15 | 212. | 1.88 % | 1. | 2.08 % |
| 16 | 142. | 1.26 % | 0. | 0.00 % |
| 17 | 122. | 1.08 % | 0. | 0.00 % |
| 18 | 132. | 1.17 % | 0. | 0.00 % |
| 19 | 85. | 0.75 % | 0. | 0.00 % |
| 20 | 73. | 0.65 % | 0. | 0.00 % |
| 21 | 51. | 0.45 % | 0. | 0.00 % |
| 22 | 36. | 0.34 % | 0. | 0.00 % |
| 23 | 36. | 0.34 % | 0. | 0.00 % |
| 24 | 25. | 0.22 % | 0. | 0.00 % |
| 25 | 11. | 0.10 % | 0. | 0.00 % |
| 26 | 0. | 0.00 % | 0. | 0.00 % |
| TOTALS | 11269. | 100.00 % | 48. | 100.00 % |

*Distance Class = Distance in 500 ft grid squares.
** Number of grid squares in a class.

Hypothesis Testing

Ho: Grid squares with sites are uniformly distributed with respect to distance to roads.

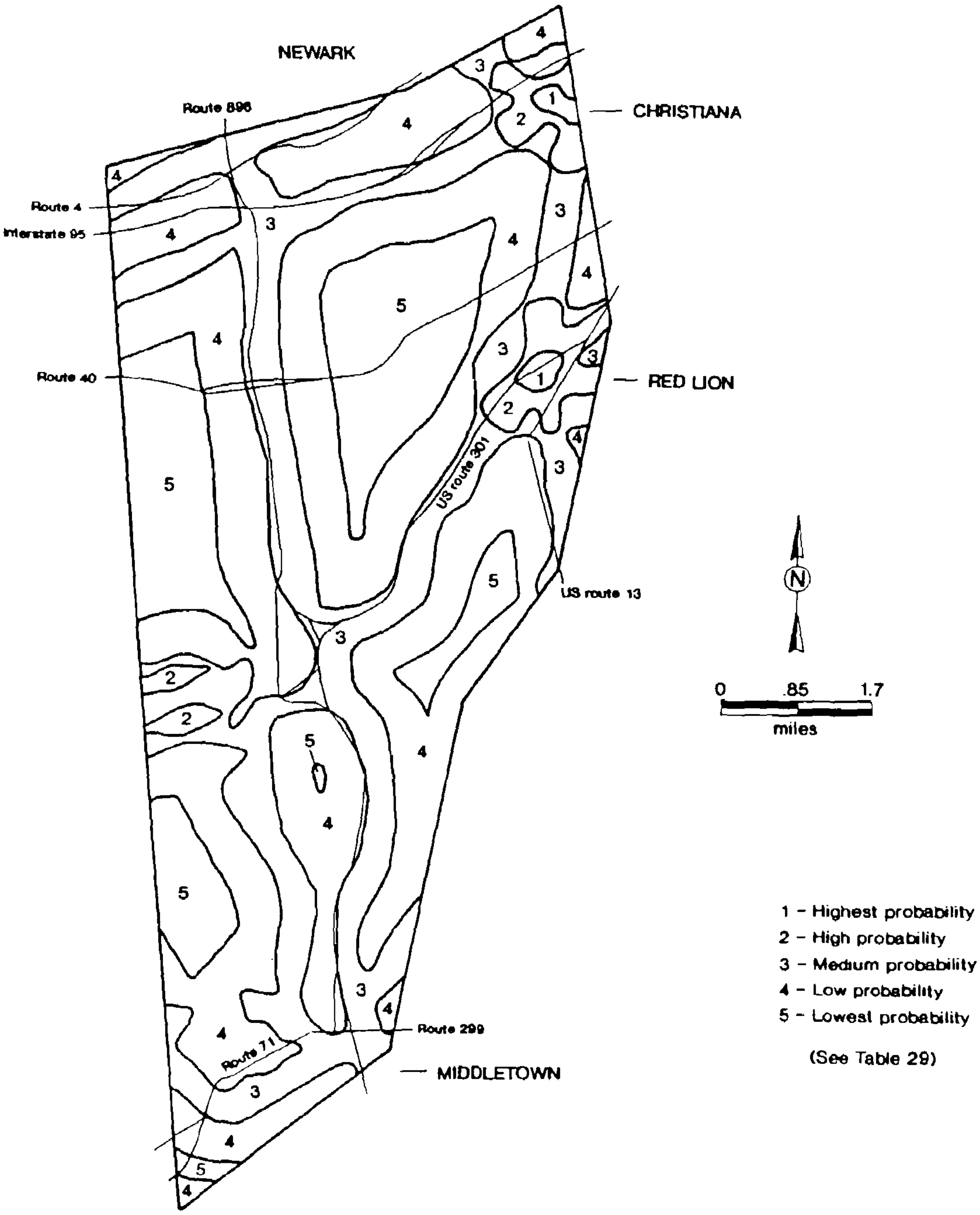
Ha: Grid squares with sites tend to be closer to roads (one-sided test).

Smirnov Test Statistic = 0.5058 > 0.2357; 0.995 < p.

Reject Ho. Sites are close to roads.

# FIGURE 33

## Pre-1770 Historic Predictive Zones




Predictive model for Pre-1770 historic sites in the Route 301 study area. Based on the distance to navigable drainages and distance to the contemporaneous road network. The difference between this map and the Pre-1730 map is the addition of several roads. Navigable drainages remain the same. Some modern roads are shown to orient the reader.

## TABLE 29

## PRE-1770 HISTORIC SITES
vs.
## PRE-1770 HISTORIC SITE MODEL

| Prob. Class | Background: Grid Squares | Background: % | Sites: Grid Squares | Sites: % | Class Name |
|---|---|---|---|---|---|
| 1 | 67. | 0.59 % | 10. | 20.83 % | High |
| 2 | 478. | 4.24 % | 9. | 18.75 % | Lower |
| 3 | 3319. | 29.45 % | 20. | 41.67 % | Highest |
| 4 | 5642. | 50.07 % | 8. | 16.67 % | Lower |
| 5 | 1763. | 15.64 % | 1. | 2.08 % | Lowest |
| TOTALS | 11269. | 100.00 % | 48 | 100.00 % | |

Hypothesis Testing

Ho: Sites are distributed uniformly into probability classes.

Ha: Sites are distributed non-uniformly into probability classes (one-sided test).

Smirnov Test Statistic = 0.4697 > 0.2358; 0.995 < p.

Reject Ho. Sites are differentially distributed into the probability classes.

## TABLE 30

## COMPARISON OF DWELLING TO ROAD DISTANCES CIRCA 1868

| | Owner Occupied | | | | Tenant Occupied | | | |
|---|---|---|---|---|---|---|---|---|
| Dist. Class* | North | % | South | % | North | % | South | % |
| 1 | 142 | 48.14 | 54 | 47.79 | 94 | 87.04 | 89 | 90.82 |
| 2 | 32 | 10.85 | 11 | 9.73 | 3 | 2.78 | 5 | 5.10 |
| 3 | 30 | 10.17 | 9 | 7.96 | | | | |
| 4 | 29 | 9.83 | 11 | 9.73 | 3 | 2.78 | 2 | 2.04 |
| 5 | 14 | 4.75 | 7 | 6.19 | 4 | 3.70 | | |
| 6 | 16 | 5.42 | 10 | 8.85 | 1 | 0.93 | 1 | 1.02 |
| 7 | 7 | 2.37 | 3 | 2.65 | 1 | 0.93 | | |
| 8 | 1 | 0.34 | 5 | 4.42 | | | | |
| 9 | 4 | 1.36 | | | 1 | 0.93 | | |
| 10 | 9 | 3.05 | | | | | | |
| 11 | 1 | 0.34 | 1 | 0.88 | | | | |
| 12 | 4 | 1.36 | 1 | 0.88 | | | 1 | 1.02 |
| 13 | 1 | 0.34 | | | | | | |
| 14 | 1 | 0.34 | | | | | | |
| 15 | | | | | | | | |
| 16 | 2 | 0.68 | 1 | 0.93 | | | | |
| 17 | 2 | 0.68 | | | | | | |
| 18 | | | | | | | | |
| 19 | | | 1 | 0.88 | | | | |
| Totals | 295 | | 113 | | 108 | | 98 | |

* Based on measurements taken from Beer's Atlas of 1868 in increments of approximately 210ft. These should be considered as ranks, not as measurements of a continuous variable.

Smirnov tests comparing the distributions north and south of the C&D Canal were not significant for either the Owner Occupied or Tenant Occupied groups.

Hypothesis Testing

Ho: Owner and Tenant occupied sites are similarly distributed in relation to roads.

Ha: Tenant occupied sites are closer to roads than owner occupied sites.

Smirnov Test Statistic = 0.4079 > 0.1393; 0.995 < p.

Reject Ho. Tenant sites tend to be closer to roads than owner occupied sites.

Comments: Almost 90% of tenant sites are <200 ft of a road, but more than 50% of owner occupied sites are >200 ft. from a road.